Mesoscale Modeling Of The Atmosphere And Aerosols

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LONG-TERM GOAL

The long-term goal is to extend our predictive skill for mesoscale meteorology and to use that meteorology to improve prediction for the transport of aerosols and gases. We recognize the need of the Navy to have predictions of mesoscale weather for operations, of tropospheric aerosol conditions for both operations and weapons systems, and of Chemical and Biological Weapons (CBW) conditions for operations and safety of mitigation strategies.

OBJECTIVES

Our objective is to study the methodology required to make accurate mesoscale predictions of the atmosphere, chemical and biological gases, and aerosols. Specific objectives include improving the initialization and prediction of surface parameters such as ground wetness, albedo, and roughness and developing an imbedded aerosol module for COAMPS for use in the design and evaluation of techniques for coupling off-line transport and dispersion models to COAMPS. This aerosol model could then be used for initialization of coarse-resolution models

APPROACH

Our approach is to couple an existing atmospheric model (i.e., COAMPS: Coupled Ocean/Atmosphere Mesoscale Prediction System) to dispersion, transport, and aerosol models and to improve their individual predictive capabilities. The prediction of mesoscale weather phenomena is attained through the use of COAMPS, which assimilates in-situ and remotely sensed information and projects this data forward in time through the use of a sophisticated numerical model of the atmosphere. This model includes both the dynamics and relevant physics that are important for the development and maintenance of mesoscale phenomena, such as land-sea breezes and mountain-valley winds. New techniques will be developed to improve surface parameters in COAMPS.

The prediction of the dispersion and transport of CBW and aerosols is accomplished by coupling COAMPS with numerical models that account for sources, sinks, transformations, advection, and dispersion. Two aerosol modeling approaches are being developed for use in studying coupling techniques. In the first, COAMPS has been loosely coupled to VLSTRACK (Vapor-Liquid-Solid Tracking). COAMPS output fields from operational runs at Fleet Numerical Meteorology and Oceanography Center (FNMOC) are used to drive VLSTRACK. Loose-coupling techniques will be tested with this implementation. In the second approach, an aerosol module has been implemented within COAMPS. This aerosol model uses the COAMPS fields at each time step; thus it is considered

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14. ABSTRACT
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15. SUBJECT TERMS

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tightly coupled, though without microphysics it is only a passive scalar model. This model has been used as validation for *loosely coupled* aerosol simulations (e.g. Gulf War Illnesses studies.) We will complete the microphysical processes in the aerosol component of COAMPS that will allow quantitative prediction of aerosols and their effects on cloud processes and atmospheric radiative transfer. This tightly coupled aerosol model will form the regional aerosol simulation component of the Navy Aerosol Analysis and Prediction System (NAAPS.) In the NAAPS concept, the regional model (COAMPS) is required for generating aerosol events at high resolution since the source area is often small-scale, as in fires, or the dynamical and topographical forcing is small-scale, as in dust storms. A high-resolution COAMPS is needed to simulate the first stages of these events. As the plume ages and reaches larger scales, the modeled distribution can then be used to insert the plume into the global model of NAAPS.

WORK COMPLETED

An improved land surface database has been incorporated into COAMPS. The database has 1-km resolution and has seasonal variations. Such a database is necessary to successfully model land-atmosphere processes. Observational studies have demonstrated significant impact from the land surface on the resulting near-surface wind, temperature, and moisture distribution.

An aerosol module has been imbedded directly inside COAMPS. This method uses the COAMPS variables perfectly (i.e. no temporal or spatial averaging.) This model was applied to the Tokaimura nuclear accident (Figure 1.) This tightly-coupled model will be used as a baseline model for development of loose coupling techniques. The method has also been modified to allow two-way interaction between adjacent grid nests. Thus it will allow plumes that are generated in the fine grid mesh to be passed to the outer grid meshes.

RESULTS

The land surface database was tested and found to be deficient in representing seasonal variations in the surface roughness caused by the annual cycle of foliage. New empirical relationships were established and incorporated into COAMPS. Comprehensive testing of the improved land surface databases with a seasonal cycle of surface roughness demonstrated improved skill in COAMPS predictions of low level winds and temperatures. The improvements to COAMPS were transitioned to operations.

The passive-scalar aerosol module imbedded in COAMPS is used to illustrate the sensitivity of modeled transport to model resolution. COAMPS, with 9- and 27-km horizontal resolution, is used to simulate a passive scalar release from Japan at the time and location of the Tokaimua nuclear accident in September 29, 1999. The 9-km resolution, 36-hour forecast shows stronger along-shore transport than does the 27-km resolution forecast. Also shown is a simulation using NAAPS driven by NOGAPS winds at 1-degree resolution. In the future, the COAMPS distribution will be used to initialize small-scale events such as these in the global aerosol model.

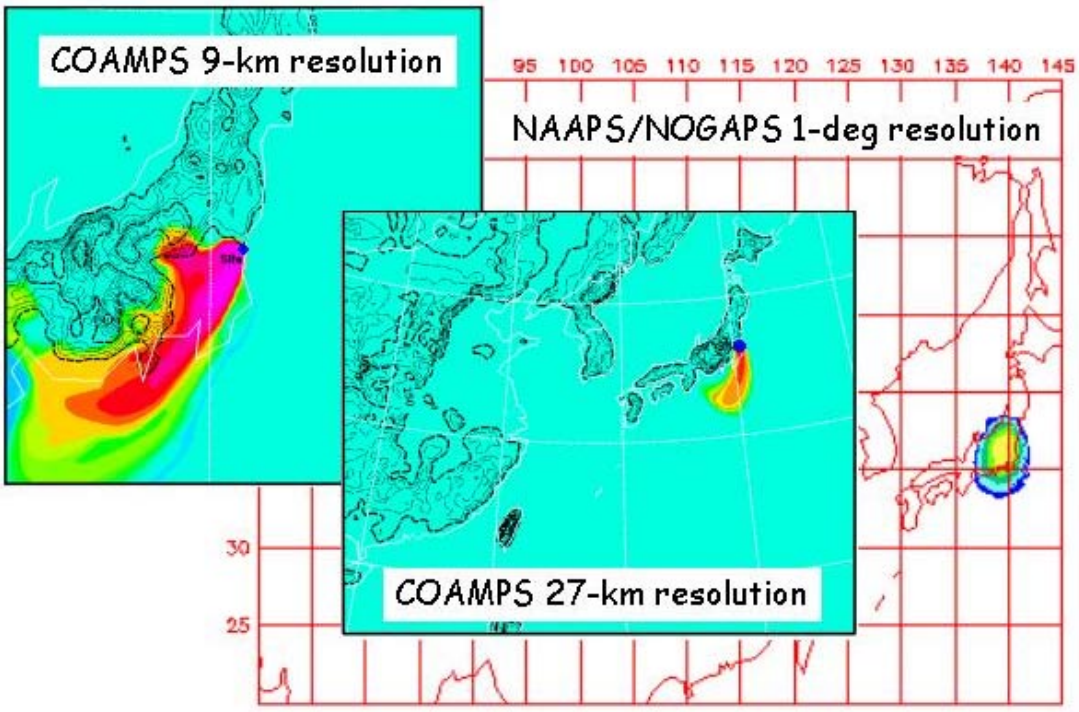

Figure 1. The passive-scalar aerosol module imbedded in COAMPS is used to illustrate the sensitivity of modeled transport to model resolution. COAMPS, with 9- and 27-km horizontal resolution, is used to simulate a passive scalar release from Japan at the time and location of the Tokaimua nuclear accident in September 29, 1999. The 9-km resolution, 36-hour forecast shows stronger along-shore transport than does the 27-km resolution forecast. Also shown is a simulation using NAAPS driven by NOGAPS winds at 1-degree resolution. In the future, the COAMPS distribution will be used to initialize small-scale events such as these in the global aerosol model.

The tightly-coupled model was also used during the Fleet-Readiness Battlefield Experiment Foxtrot (FBE-F). In this instance, the model was run on the Tactical Atmospheric Modeling System-Real Time (TAMS-RT) in Bahrain, producing real-time forecasts of the transport of a passive scalar from a continuous source in Bahrain. The experiment demonstrated the benefit of having the transport forecast available in real-time. The visualization products included the COAMPS dynamical fields and animation clearly showed the evolution of the plume within the dynamical context. However, the tightly coupled application is practical only for dynamically driven aerosols (e.g. dust storms) or for planned (e.g. known) emissions.

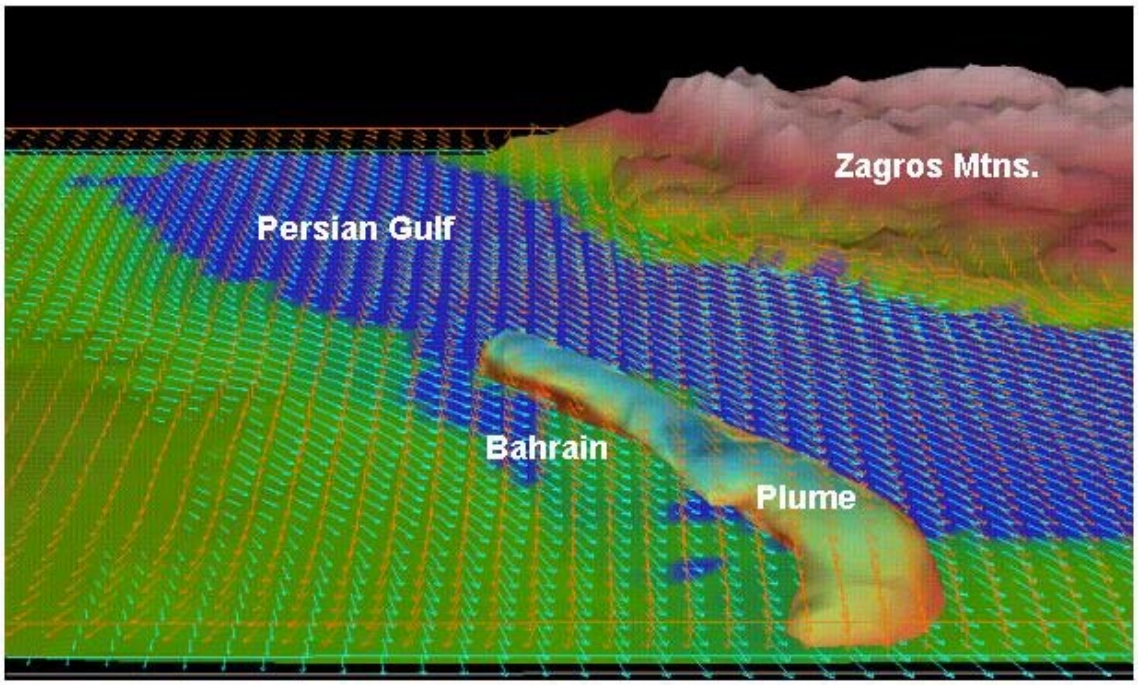

Figure 2. For the 6.4 COAMPS OS program, the passive-scalar aerosol module imbedded in COAMPS and TAMS-RT was used during FBE-F in December 1999 in the Persian Gulf. The graphic shows the 12-hour forecast of surface and boundary layer winds (green and orange arrows, respectively) and the nominal outline of a passive scalar emitted continuously in the boundary layer at Bahrain.

IMPACT/APPLICATION

COAMPS has been used to gain a new understanding of the sensitivity of mesoscale dynamics and processes to resolution and surface characteristics. A highlight of this body of work is the application of the model to a new area: CB and aerosol modeling. This study demonstrates the promising future capability of a real-time, high-resolution modeling for these applications.

TRANSITIONS

Developments from this program will transition to existing 6.4 programs for applications within COAMPS and TAMS-RT and for subsequent transition to Fleet Numerical Meteorology and Oceanography Center (FNMOC) and other potential sites for operational use.

RELATED PROJECTS

Related projects at NRL include 6.1 Coastal Aerosol Processes (BE –33-02-4K) and 6.2 Coastal Aerosol Distribution by Data Assimilation (ONR Award # N0001400WX20181). Related 6.4 projects within PE 0603207N , task X-2342 (SPAWAR PMW-185), include Small-scale Atmospheric Models, which focuses on the transition of COAMPS improvements to FNMOC, and On-Scene Tactical Atmospheric Forecast Capability, which focuses on the transition of COAMPS upgrades to the regional METOC centers as part of TAMS-RT.

REFERENCES

None

PUBLICATIONS

Liu, M. and D. L. Westphal: Sensitivity Study of model resolutions on mineral dust production. Presented at the 1999 Fall A.G.U. Meeting, San Francisco.

Liu, M. and D. L. Westphal: A Study of the Sensitivity of Simulated Mineral Dust Production to Model Resolution. Submitted to *J. Geophys. Res.*, March 2000.